Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 91 (2016) 268 – 275

Procedia Computer Science

Information Technology and Quantitative Management (ITQM2016)

Unconventional Emergencies Management Based on Domain Knowledge

Mengyan Feng, Aihua Li[a]*, Chuanliang Jia, Zhidong Liu

[a]School of Management science and Engineering, Central University of Finance and Economics, Beijing, 100081, China

Abstract

Unconventional emergencies generally lack experiences, and the development of the situation is always dynamic. So it's easy to pose a threat to the security and stability of the society. Byintroducing the standardization of domain knowledge in emergency decision system and giving an effective remedy for the emergency decision making method based on artificial intelligence, domain knowledge and ontology in the field of unconventional emergencies are helpful to solve the problem of the low degree of the pertinence and participation of the experts. It has some inspiration for the future emergency management.

Peer-review under responsibility of the Organizing Committee of ITQM 2016

Keywords: Unconventional Emergency; Emergency Management; Domain Knowledge; Ontology; HTN

1. Introduction

The famous German sociologist Ulrich Beck proposed a concept called "Risk Society" in his literary work *Risk: Towards a New Modernity* in 1986. He thought today's post-industrial society were fraught with risks, and this society was a society full of disastrous. Over a period of decades, national emphasis of social risk management is increasing day by day. And for the conventional emergencies it has corresponding more perfect emergency plans. But with the change of social development, the progress of science and technology and the change of the natural environment, all kinds of unconventional emergencies have a significant increase in the occurrence probability in the world. Because of its rare and unpredictable, the state and the departments almost have no corresponding available and effective contingency plans for unconventional emergencies. Coupled with the current node association between the various social subsystems increasing, the degree of interdependence increases.Once it occurred, it would have a serious impact on the whole society. In recent

* Corresponding author. Tel.: +86-10-62288622; fax:+86-10-62288622.
*E-mail address:*aihuali@cufe.edu.cn.

Peer-review under responsibility of the Organizing Committee of ITQM 2016
doi:10.1016/j.procs.2016.07.073

years, there are some unconventional emergencies occurred in China, like snow and ice storms in southern China in 2009, Dalian oil pipeline explosion in 2010, and Tianjin Binhai New Area of dangerous items explosion in 2015.

Non-conventional emergencies usually have characteristics such as paroxysm, the tendency to spread, uncertainty, severity, community and so on [1]. So it has the following challenges in emergency decision making: (1) The urgency of time. Because of the severity of the unconventional emergency situation, the general reaction and instruction time for decision makers is short. (2) Inapplicability of traditional management. Due to the low rates of such an event, and its evolution rules are generally unknown, the management is more difficult. So we cannot use the traditional "prediction-deal with" management mode, and we should change to the emergency management mode of "scenario-response". (3) Uncertainty of subsequent derivation. Emergencies are generally in the process of continuous dynamic change, the future evolution of the situation is not clear, which has brought great challenges and complexity to the management and decision-making [2].

From this dangerous goods warehouse explosion incident in Tianjin Binhai New Area, it can be seen that Chinese government's emergency treatment of unconventional emergencies need to be improved. A variety of publications follow-up reports mentioned the relevant institution lack of emergency management ability and scientific approach, mishandling of unexpected fire, and all these led to many casualties of rescue firefighters and related personnel. Firefighters were lack of training and knowledge of dangerous goods. In addition, the commanders on the scene, although with some relief experience, but may not understand the characteristics of high-risk chemicals and lack of scientific command ability. And these are related to the domain knowledge of the corresponding professional. In this paper by introducing the standardization of domain knowledge in emergency decision system and giving an effective remedy for the emergency decision making method based on artificial intelligence, domain knowledge and ontology in the field of unconventional emergencies are helpful to solve the problem of the low degree of the pertinence and participation of the experts. It has some inspiration for the future emergency management.

2. Domain Knowledge Structure of Unconventional Emergencies

2.1. Domain Knowledge

Domain knowledge refers to the knowledge framework which is composed of experts' experience, skills and management quality in a certain industry. In simple terms, it is the specialized knowledge and skills in the field of industry[3]. It's like an organization and reorganization of knowledge, as well as the explicit and tacit knowledge, through the acquisition, organization, distribution, application of knowledge, to achieve knowledge sharing and knowledge innovation [4]. Domain experts at the scene to deal with the emergency rely upon the accumulated rich experience and intuition over the years to find out the solution and then to use logic to prove the feasibility and effectiveness of the proposed method [5]. Their thinking process is like Fig.1.

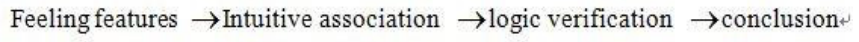

Fig. 1.Thinking Process

Digitization and materialization of domain knowledge is equivalent to provide the general people the process of "Intuitive association" shown above. Domain knowledge will be able to save a lot of time costs and human capital, and to ensure the efficiency and quality.

2.2. Domain Knowledge Structure of Unconventional Emergencies

The handling process of unconventional emergency is similar to the common emergency. But because of its scarcity, there is no large number of historical cases we can refer to, just the experts' domain knowledge and prediction. According to DSE3M model proposed by Wen et al [6], based on the different stage of life cycle of emergencies, we need to divide domain knowledge into four blocks, which are scene representation, evolution mode, decision making and resource scheduling.

(1) Scene Representation

No matter whether the emergency is conventional or not, the situation must be the basis and the foundation for the decision maker. Because of the uncertainty and the community of the unconventional emergencies, the statement of the situation must be very clear and accurate. At the same time, it is also an important basis for assessing the emergency resource for commanders. According to the scenario model proposed by Zhong et al [7], the unconventional emergency scenario is that the disaster consists of four elements: the environment event, triggering elements of the event, factors affecting the development of events, hazard bearing body elements. In unconventional emergencies, what the leaders repeatedly mention is that the situation of the event occurred. To know the future of the "potential" must first know the current state. Only by fully understanding the status of the event, can we have a small deviation in predicting the future development of the event by the next scientific means.

(2) Evolution Mode

Unconventional emergencies will not be fixed in its occurrence situation and it has its own development process. Due to the interaction of various elements, the nature of the event, event type, hazard level, scope and other aspects will change. And the evolution of the emergent events can be divided into four forms, which are spreading, conversion, derivation and coupling [8]. In case of spreading, domain experts need to monitor the development of events in all cases, and makethe correct measures based on the past experienceto prevent the spread. In addition experts should put a threshold to monitor the conversion of unconventional emergencies. Conversion emergencies often have a logical causality.When the factors accumulate to a certain extent, it will lead to the occurrence of another event. Generally it has a strong correlation between them. Furthermore, derivation needs more attention of domain knowledge. Because derived events have not too strong correlation and cannot be predicted from the past case base. Most of them are caused by an accident, as well as some burst event caused by inappropriate solutions. Coupling refers to the interaction between the incidents, which also requires experts assuming in advance.

(3) Decision Making

According to analyzing on the above scene representation, evolution mode and the existing experience, decision makers pick up the effective knowledge of the existing similar cases and the scene related emergency plans. Then they do some appropriate adjustment to obtain the final integration of the root measure, which has strong guidance, to carry out the right relief measures. However the matching results with the past cases may not be effectively available. In fact, our knowledge of every unconventional emergency is known, but it is only a few pieces of knowledge. For example, there are a lot of studies of identification process about volcano eruption, although they are fragment knowledge. Because the volcano eruption hardly occurs, the knowledge won't appear in the emergency case library.

(4) Resource Scheduling

Domain knowledge of resource scheduling refers to the transfer of the human, material,financial and information resources in the decision-making process after the incident. Among them, domain knowledge of manpower scheduling in emergency implementation process refers to the information about the command authorities, action team and cooperative sector, including geographic location, ease of scheduling, the department level and other information. Material scheduling knowledge refers to the geographical location of the material and financialresources, the right to call the required permissions, responsible departments,

thenumber of calls, the related costs and other information. Information resources scheduling knowledge refers to the effective transfer of information in the process of implementation, including the transfer media and the transfer way. Due to the limited and scarce resources, the final plan should be based on the resource scheduling [9].

3. Ontology Construction of Unconventional Emergencies

3.1. Ontology

In 1993, Gruber originally defined the notion of an ontology as an 'explicit specification of a conceptualization' [10]. Studer gave a clear and comprehensive explanationbased on the characteristics of ontology: ontology is a formal, explicit specification of a shared conceptualization [11]. It is a method used to describe, express, share and reuse the knowledge. Overall, the ontology is to make domain knowledge formalization, and make it easier for computer processing. So that it can achieve the goal that the knowledge can be shared between people, between man and machine.

Now there are many studies about using ontology to solve problems about emergencies. Onorati et.al modeled an ontology on accessible evacuation routes for emergencies [12]. Jihan and Segev presented a method for merging ontologies and logic rules to represent humanitarian needs for emergency disaster response [13]. Wang et.al built an effective emergency plans crawler which based on domain ontology of emergency plans to achieve efficient collection of emergency plans from the web [14].

3.2. Ontology Construction of Domain Knowledge Based on HTN

Because the unconventional emergency is an unstructured or semi-structured problem, the traditional decision theory and methods are difficult to adapt [15]. At present, the main methods to solve this problem are three ways: emergency decision making method based on emergency plan[16]、emergency decision making method based on case-based reasoning[17]、emergency decision making method based on intelligent planning. By comparing these three ways, Li found that the application range of emergency decision making method based on intelligent planning is wider, more flexibility, and it has faster processing speed. But the one and only weakness is that its relevance and the degree of the participation of the experts is not high enough [18]. The HTN planning model is a most widely used intelligent programming model, which has been applied to the field of crisis management, production scheduling, etc. [19] So introducing domain knowledge ontology structure based on HTN (Hierarchical Task Network Planning) can solve this problem.

Model structure is shown in Fig.2.

Unconventional domain knowledge should include unconventional emergency case base in the past, conventional emergencies case base and domain knowledge of expertise.We divide the unconventional emergency domain knowledge totwo-tier structure, Case Base and Expected disposal, which we have proposed in section 2, in accordance with whether the case has actually happened.

The unconventional and conventional cases have occurred are in the same case base. Then separate the case base into three subclasses: Situation, Emergency Planningand Resource Scheduling.Furthermore, divide Situation into two subclasses, including:(1) Event Property: it is mainly defined on the property of the incident itself. The event should be classified as natural disasters, accidents disasters, public health and social security four categories according to the*General Emergency Plan for National Public Emergency*. The state level, economic loss, personnel casualty and so on are all event property. (2)Environment: it's mainly divided into two categories of social environment and natural environment. The natural environment can be subdivided into hydrology, geology meteorologyand traffic to describe. Social environment can be divided into administrative areas, disaster bearing audience gathering point and the placement point, etc.

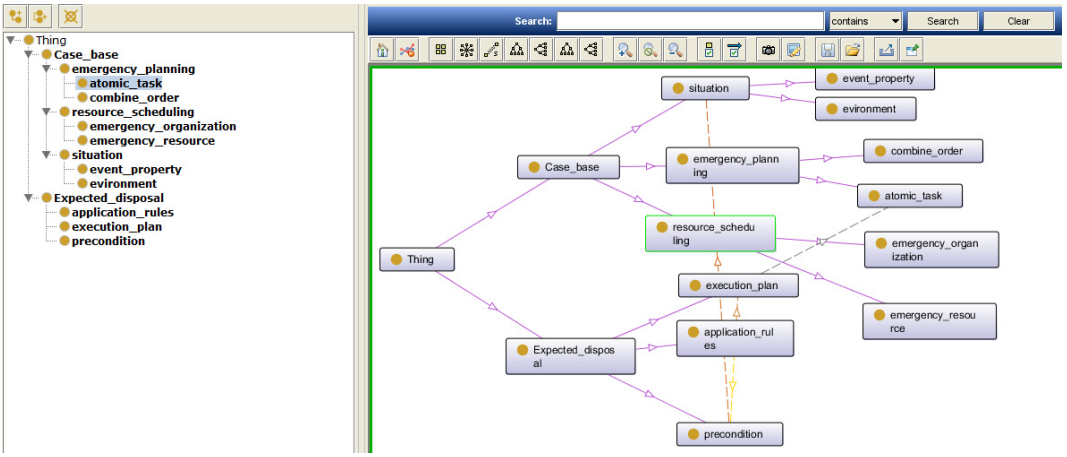

Fig.2. Ontology Structure

Resource scheduling should be subdivided into two sub categories: (1) Emergency Resource: including the manpower, financial, material, information and other resources that decision makers can use in the process of emergency. We can create four sub-categories: "personnel resources", "material resources", "financial resources", "information resources". "Personnel resources" can be divided into "transport officer", "store personnel", "emergency personnel", "medical units", “police" and other.Specific division can be divided according to each different case.The detailed description like the number of personnel and the distance from the rescue point should be stated."Material resources" includes "life-support supplies" and "life guarantee supplies" and "rescue equipment and facilities", this part should list the name and number of the materials used and the money used. Information resources, including whether the main communication equipment is normal and thedescriptions of information transfer methods between the departments. (2) Emergency Organization: including the command authorities, action team and cooperative sector. Such attributes should be described as (name, administrative level, the higher unit, department location, department supervisor, involving tasks, etc.).

The basic idea of HTN planning is mainly reflected in the Emergency Planning. Based on knowledge, the task is decomposed layer by layer until the atomic task can be completed by executing the simple instruction action.The completion of the atomic task has nothing to do with the completion of other related tasks, and only depends on the resources in the implementation process whether it is sufficient to support the completion of the task.Combine order is an ordered set of atomic tasks, which is the sequence of atomic tasks.Emergency task description should be like this:(task name, task type, task release time, execution time, the place of execution, type of resource consumption, resource consumption quantity, task execution premise, the implementation effect)[20].

And the expert domain knowledge experience is mainly reflected in the Disposal Expected.Experts can deduce the various possibilities of the evolution mechanism of the emergency through the domain knowledge. And in real life, the emergency evolution does not achieve every state, but each direction of evolution has its potential.The part of expected disposal makes upthe evolution mechanism and treatment that has not happened yet in real life. It guarantees the full use of domain knowledge. So that the professional decision-making can be implemented without the experts in the field and reduce the further expansion of the emergency situation caused by the non-professional command.Its main approach is envisaged by the experts for the evolution of a series of unconventional emergency situation that may occur and setup tasks according to this. Disposal Expected includes precondition, execution plan and application rules. The precondition is envisaged by the experts. The data is stored in the Situation, which can be assembled and disassembled. And the execution plan

can be ordered combination of atomic tasks to form an effective task chain. As for the application rules are mainly represented in some kind of condition, and the rules of some kind of scheme are required.

4. Framework of Emergency Decision Model Based on Ontology

In this paper, a general framework of unconventional emergency handling based on ontology is presented in Figure 3. The key information is extracted from the historical cases and domain knowledge according to the second section. And the knowledge needs to be entered in accordance with the hierarchical classification, as well as determine the relationship between the hierarchy, category and type. Use the relational statement to integrate the key information of each system. At the same time, it is necessary to define the data attributes of each level category, which is convenient for the latter to add new knowledge fragments. The pieces of knowledge in the ontology model can be secondary mined to get new association rules or domain knowledge to achieve the goal of maintenance and the update of the ontology. We can also second mine the new case to extract key information then addit into the ontology. The matching service between the ontology and the object case can choose the usual methods in the past, such as the Liu's Similarity Model [21], to obtain the preliminary decision results. Then compare the decision result with the reality again. If the user's need is satisfied, then we can implement. If not, do re-matching service and then fine-tune to get the most satisfactory solution. Afterwards, recompile the case, extract the key information and add it into the ontology as a new case.

5. Conclusion and Prospect

At present, the domain knowledge has become more and more popular and been accepted by the public [22]. And it is very necessary to apply the domain knowledge in the field of emergency management. Unconventional emergencies once occurred, due to the urgency of the timeandprofessionals can't arrived on site at the first time to direct rescue, rescue in the wrong way tend to cause more casualties and greater economic losses, and may lead to a certain degree of turbulence on the stability of the society. The standardization of domain knowledge and introducing it into the emergency decision system can help the decision makers to respond more effectively to the non-conventional emergencies. By introducing the standardization of domain knowledge in emergency decision system and giving an effective remedy for the emergency decision making method based on artificial intelligence, domain knowledge and ontology in the field of unconventional emergencies are helpful to solve the problem of the low degree of the pertinence and participation of the experts. It has some inspiration for the future emergency management.If there was an ontology construction model for the emergency management of Tianjin Binhai New Area incident, commanders would understand the special features of the stored chemical drugs, and would not command the fire brigade to rush into the fire, which led to a large number of casualties. The chemical protective group would come to the scene earlier to investigate for risk, and the government would predict that it would spread rumours and cause paralyzed traffic problems. So that commanders can take out the appropriate measures to make the impact of the crisis on society reduced to a minimum.And we will further study the validity of the model. For example, a case study will be tried to show the usefulness of the model.

Acknowledgement

This research is partially supported by the grants (91324203and71401188) from the National NSFC, and the CUFE-VU international research funding and Program.

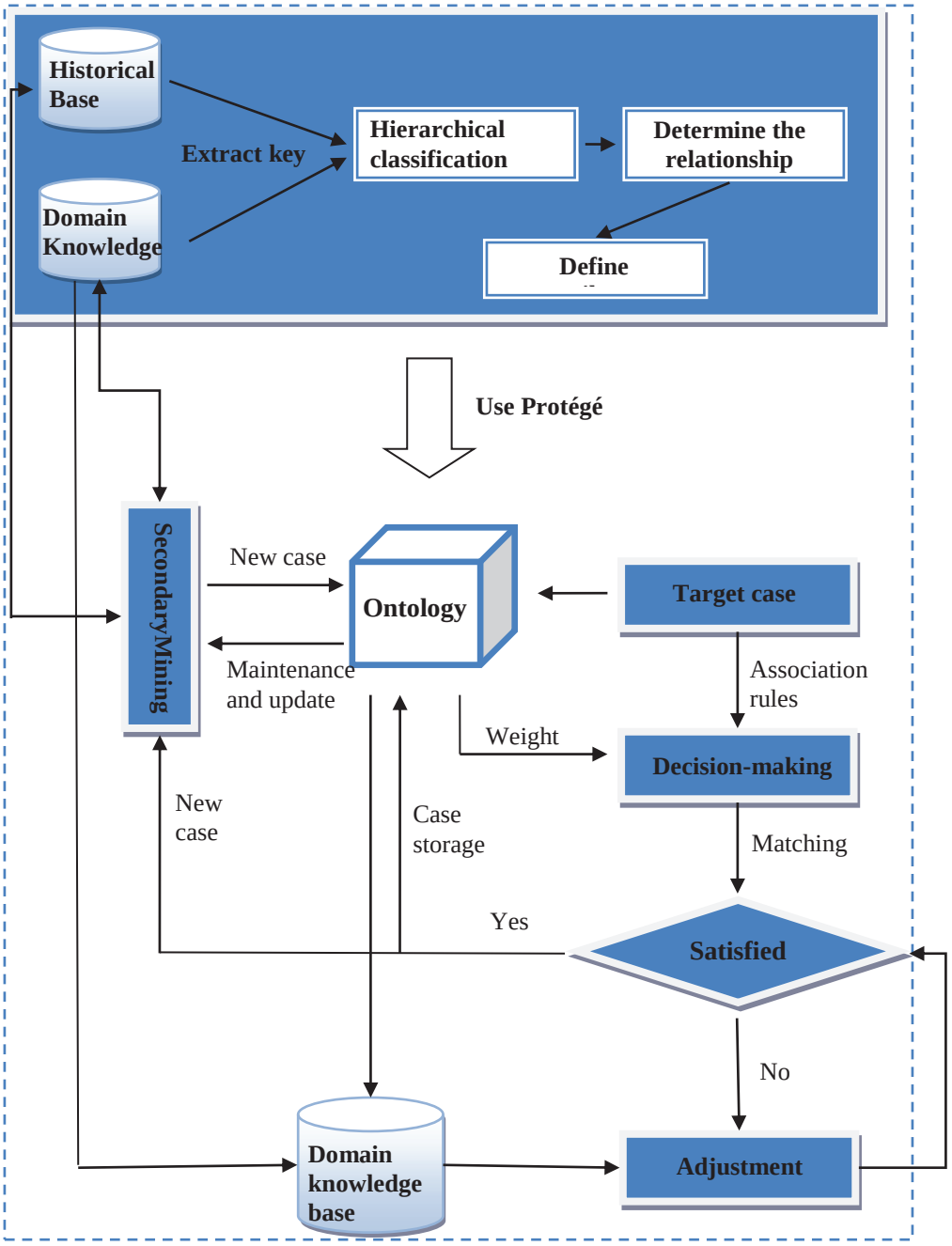

Fig.3. Frame work

References

[1]John Cosgrave. Decision making in emergencies. Disaster Prevention and Management, 1996,5(4):28-35.
[2]Xiaofang Yuan. Research on Key Technologies of Emergency Decision-making for Unconventional Emergency Based on Scenarioanalysis and CBR. Xi'an University of Science and Technology,2011.
[3]Shoucai He et al. Database Encyclopedia http://xuewen.cnki.net/read-R2011090780000291.html
[4]Liuhua Wei. Research on Semantic Web Ontology Based on description logic.University of Yangzhou，2008.
[5]Tian Gao. State Evaluation and Evolution Analysis of Tourism Emergency Based on Domain Knowledge. Beijing University of Posts and Telecommunication, 2007.
[6]Li Wen, ShumingZhou, YanzhangWang. The Ontology Model of Emergency Event Based on Decision Support. Journal of Intelligence，2010, 29(2), p.131－134.
[7]Qiuyan Zhong et al. Research on Unconventional Emergency Scenario Model Based on Knowledge Element. Information Science, 2012, 30(1),p.115-120.
[8]YunfengZhao. Emergency Management of Unconventional Emergencies. Fudan University,2009.
[9]WeidongHuang et al. Research on Ontology － based Knowledge Representation of Food SafetyEmergency Management. Computer Techonology and development, 2015, 25(3), p.223-227.
[10]GruberT.R.. A Translation Approach to Portable Ontologies. Knowledge Acquisition,5(2), p.199-220,1993
[11]StuderR,BenjaminsV.R,FenselD. Knowledge engineering priciples and methods. Data and Knowledge Engineering, 1998,25(1-2),p.161-197.
[12]Onorati T, Malizia A, Diaz P, Aedo I. Modeling an ontology on accessible evacuation routes for emergencies. Expert Systems with Applications, 2014, 41(16), p.7124-7134.
[13]Jihan S, Segev A. Humanitarian Assistance Ontology for Emergency Disaster Response. Intelligent Systems IEEE, 2014, 29(3), p.6-13.
[14]Wang J et al. Crawling Strategy Based on Domain Ontology of Emergency Plans. International Conference on Education Technology & Information Systems, 2013, 65(6), p.645-648
[15]WAN Hussainet al. Conceptual model of intelligent decision support system based on naturalistic decision theory for reservoir operation during emergency situation. International Journal of Civil &Environment Engineering, 2011, 11(2), p.6－11.
[16]Allan McConnell, Lynn Drennan. Mission Impossible? Planning and preparing for crisis. Journal of Contingencies and Crisis Management,2006, 14(2), p.59－70.
[17]Rollon Eet al. Towards the distributed management of emergencies: forest fires case study. 1stIJCAI Work-shop on Environmental Decision Support Systems, 2003, p.77－82.
[18]MingleiLi et al. Research on Unconventional Event Emergency Decision-making Methodologies. China Safety Science Journal,2012,22(3), p.158-163.
[19]Malik G,Dana N, Paolo T. Automated Planning: Theory and Practice. Morgan Kaufmann: Elsevier, 2004, p.257－258.
[20]KuangyuLiu. Emergency Domain Knowledge Modeling for HTN planning. Huazhong University of Science and Technology,2012.
[21]Qun Liu, SujianLi. Based on the "Cnki" lexical semantic similarity calculation. Institute of Computing Technology, Chinese Academy of Sciences, 2002.
[22]JiaminZhao. Domain knowledge, the next hot word in the Internet.http://www.hbrchina.org/2015-07-24/3196.html.2015.07.24.